EVALUATION OF HOT MIX ASPHALT MIXTURES CONTAINING RECLAIMED ASPHALT PAVEMENT AND CRUMB RUBBER

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Dalam tahun-tahun kebelakangan ini, getah serbuk (CR) telah digunakan secara meluas dalam turapan asfalt, banyak penyelidikan menunjukkan bahawa campuran asfalt getah (CR) adalah bahan yang mesra alam dan turapan asfalt kitar semula (RAP) adalah turapan asfalt lama yang telah dikeluarkan dari jalan raya dengan pengilangan atau penyingkiran kedalaman penuh. Penggunaan RAP dalam asfalt campuran panas (HMA) menghilangkan keperluan untuk melupuskan turapan asfalt lama dan memelihara pengikat asfalt dan agregat, menghasilkan penjimatan dan manfaat kos yang signifikan kepada masyarakat. Makalah ini membentangkan kajian mengenai HMA dengan campuran RAP yang berbeza dan perkadaran getah serbuk yang dilakukan untuk menilai sifat-sifat mekanik dan prestasi campuran asfalt yang mengandungi RAP yang berlainan nisbah getah serbuk. Kaedah rekabentuk campuran Marshall digunakan untuk menghasilkan campuran kawalan dan campuran asfalt yang mengandungi 40% RAP, 40% RAP 2% CR dan 40% RAP 6% CR selaras dengan Spesifikasi Jabatan Kerja Raya, Malaysia (JKR/SPJ/2008) untuk penggredan asfalt AC14 yang padat dan ujian parameter Marshall. Ujian aliran kestabilan dan aliran Marshall merupakan analisis yang dilakukan untuk memastikan keputusannya adalah mematuhi keperluan spesifikasi yang telah ditetapkan. Ujian modulus berdaya tahan telah dilakukan untuk mengukur ketegangan yang boleh dipulihkan bahan di bawah tegasan berulang tanpa mencapai batas kegagalan. Ujian rayapan dinamik dilakukan untuk mengukur potensi rantaian campuran asfalt. Keputusan yang diperolehi menunjukkan bahawa tidak terdapat perbezaan yang ketara dalam ujian kestabilan dan aliran Marshall, dan modulus berdaya tahan antara campuran asfalt dengan RAP, getah serbuk dan campuran kawalan. Hasil ujian menunjukkan campuran kitar semula adalah setara prestasi HMA konvensional dari segi kestabilan Marshall, ujian aliran dan modulus berdaya tahan.

ABSTRACT

In recent years, crumb rubber (CR) has been applied widely in asphalt pavement. Many researchers have indicated that crumb rubber (CR) asphalt mixture is an environmentally friendly material and Reclaimed Asphalt Pavement (RAP) is old asphalt pavement that has been removed from a road by milling or full depth removal. The use of RAP in hot mix asphalt (HMA) eliminates the need to dispose old asphalt pavements and conserves asphalt binders and aggregates, resulting in significant cost savings and benefits to society. This paper presents a study on HMA with different RAP mix and crumb rubber proportions carried out to evaluate the mechanical properties and performance of asphalt mixes containing RAP different proportions of crumb rubber. Marshall Mix Design Method was used to produce control mix and asphalt mixes containing 40% RAP, 40% RAP 2% CR and 40% RAP 6% CR in accordance with Specifications for Road Works of Public Works Department, Malaysia (JKR/SPJ/2008) for AC14 dense graded asphalt gradation and parameter Marshall test. Marshall stability and flow test was analysis performed to ensure that the result is compliance with specification requirements. The resilient modulus test was performed to measure recoverable strain of the material under repeated stress without reaching the failure limit. The dynamic creep test was performed to measure the rutting potential of the asphalt mixture. The results obtained showed that there was no substantial difference in Marshall stability and flow test and resilient modulus between asphalt mixes with RAP40, RAP40CR2, RAP40CR6 and the control mix. The test results indicated that recycled mixes performed as good as the performance of conventional HMA in terms of Marshall Stability, flow test and resilient modulus.

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LIST OF SYMBOLS

mm	Millimetre
kPa	Kilo Pascal
g	Gram
N	Newton
cm^3	Centimetre cubic
$^+$	More
-	Less
$\pm$	More and less
%	Percentage
$^\circ C$	Degree Celcius

LIST OF ABBREVIATIONS

AC	Asphalt Content
ASTM	American Society for Testing and Materials
AR	Asphalt Rubber
ARS	Asphalt Rubber Stone
BS	British Standard
RAP	Reclaimed Asphalt Pavement
CR	Crumb Rubber
CRM	Crumb Rubber Modified
CRP	Crumb Rubber Powder
CW	Control Warm
FHWA	Federal Highway Administration
HDPE	High Density Polyethylene
HMA	Hot Mix Asphalt
JKR	Jabatan Kerja Raya
LVDT	Linear Variable Displacement Transducer
MQ	Marshall Quotient
NAPA	National Asphalt Pavement Association
RAC	Rubber Asphalt Concrete
SMA	Stone Matrix Asphalt
US	United State
UTM	Universal Testing Machine
VMA	Voids in Mineral Aggregates
WMA	Warm Mix Asphalt
WR	Reclaimed Warm

CHAPTER 1

INTRODUCTION

1.1 Background

The pavement industry has long emphasized the need to reuse RAP materials obtained from asphalt pavements that have been removed from road reconstruction or coating processes. According (Nataadmadja, Prahara, and Christian 2017), these materials can be crushed and filtered for use as a high quality and good aggregate. Therefore, many researchers are studying the RAP Aggregate for reuse in future road construction projects. The advantages of reusing RAP aggregate in road construction, it reduces the cost of materials and waste and has good performance when mixed with natural aggregates. However, the aggregate RAP has several disadvantages, such as the interaction questioned between virgin material and recyclable material and increasing the stiffness of the RAP binders. Thus, the economic and environmental principles of the use of RAP in the asphalt mixtures, it is found that using RAP can increase the resistance of rutting and conducting and mixing of other virgins.

Crumb rubber is easily accessible due to the sintering industrial waste material, indirectly making an effort to recycle unused material. According (Xiao et al. 2008), most laboratory and field experiments have shown that rubber asphalt concrete (RAC) generally demonstrates endurance, crack reflection, fatigue and slip resistance, and resistance to rutting not only in layers, but also in layers absorbing membrane pressure (Xiao et al. 2008). Now, various rubber sizes are used in mixes around the globe. In addition, studies show that fatigue behaviour is better than conventional mixtures and can improve endurance of asphalt. However, the influence of two by products (CR and RAP) mixed with virgin blend was not clearly identified. Specifically, the effect of rubber size or the kind of physical properties of recycled blends is not investigated in detail. Therefore, increasing the supply and increasing cost of materials, the use of RAP and CR

is an appropriate way of preserving non-renewable, aggregate and bitumen resources used for asphalt mixtures

1.2 Problem Statement

Nowadays, a structural failure in highway pavements such as cracks and rutting have always been an issue in highway construction. It is because the pavement design life should be considered up to 10 years Therefore, the continuous demand on the construction materials lead to the depletion of natural resources and increase the waste materials. Based on statistic in National Asphalt Pavement Association (NAPA) in 2011 the average amount of RAP used in asphalt mixtures nationwide increased from approximately 16% in 2009 to about 18% in 2010. The recycling of asphalt pavement materials is found to be the best method to minimize the usage of natural resources and to solve the materials disposal issues.

Moreover, asphalt cannot withstand drastic weather changes because asphalt is hard in cold environments and soft in hot environments. Previous studies showed that number of failures represented by the low temperature cracking, fatigue cracking, and the rutting (or permanent deformation) at high temperature, causing its quality and pavement performance to decrease. Therefore, the waste tyres which it is one of the environmental problems in Malaysia. This problem needs to be urgently solved because waste tyres are not easily disposed. Statistic from Ministry of Environment Malaysia stated that, waste tyres in Malaysia increase every year because the waste tyre is depending on amount of road user in Malaysia. Recycled the tyres will be the one of way to save the space.

Many studies have proved that RAP and crumb rubber could be incorporated into the pavement mixture. It is supported researcher by (Saberi.K, Fakhri, and Azami 2017), the influence of two by products (crumb rubber and RAP) mixed with virgin mixtures together has not yet been identified clearly. Especially, the effects of rubber size of recycled mixtures have not been investigated in detail.

Besides that, the waste material should be reuse to make other product instead of been disposed or burned it because this process will affect and destroy the nature environment. Sustainability of production systems is a key global issue for governments,

industries and society, particularly in the timber processing and manufacturing sector. The purchase price of materials can also be one of the main determinants in deciding what material to use in construction projects. Apart from economic costs, costs derived from pollution and energy, as well as social aspects must be considered in choosing building materials.

1.3 Objective of Study

The aim of this study was determine the evaluation of hot mix asphalt containing reclaimed asphalt pavement and crumb rubber mixture. The aim was achieved through the following objectives:

i. To determine the effect of reclaimed asphalt pavement and crumb rubber to the asphalt mixture durability.

ii. To determine the effect of reclaimed asphalt pavement and crumb rubber in recoverable strain of the material under repeated stress of asphalt mixture.

iii. To determine the effect of reclaimed asphalt pavement and crumb rubber in rutting potential of the asphalt mixture.

1.4 Scope of Study

The scope of the study as follows:

i. HMA mixtures were designed by incorporating RAP and crumb rubber which are compatible with the conventional bituminous mixture.

ii. Mixture gradations used in this study were design in accordance to JKR (JKR, 2008).

iii. RAP and CR will have acted as aggregate replacement in RAP used 40% and different percentage crumb rubber used 2% and 6%.

iv. The size of RAP and crumb rubber replacement in asphalt mixture were below than 5 mm and 0.150 mm.

v. Grades of fresh bitumen (60/70 PEN) were utilized in this study.

vi. Performance of the mixtures was evaluated based on laboratory samples and tests.

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